Architecting Ourselves:
Schema to Facilitate Growth of the International Space Architecture Community

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Abstract

Over the past 20 years, Space Architecture has attained some early signs of legitimacy as a discipline: an active, global community of practicing and publishing professionals; university degree programs; a draft undergraduate curriculum; and formal committee establishment within multiple professional organizations.

However, the nascent field has few outlets for expression in built architecture, which exacerbates other challenges the field is experiencing in adolescence: obtaining recognition and inclusion as a unique contributor by the established aerospace profession; organizing and managing outreach by volunteers; striking a balance between setting admittance or performance credentials and attaining a critical mass of members; and knowing what to *do* – beyond sharing common interests – to actually increase the market demand for space architecture.

This paper develops a conceptual model, adapted from the way research-and-development non-profits and universities tend to be organized, that could help amplify the reach and effectiveness of the international space architecture community. The model accommodates current activities and published positions, and increases involvement by allocating accountability for necessary professional and administrative activities. It coordinates messaging and other outreach functions to improve brand management. It increases sustainability by balancing volunteer workload. And it provides an open-ended structure that can be modified gracefully as needs, focus, and context evolve.

This organizational model is offered up for consideration, debate, and toughening by the space architecture community at large.

Problem Statement

Space architecture is a new field, without clear, inherited precedents for organizing its definition, coordination, expansion, or codification. Four barriers are apparent: inertia against novelty; the fragility of reliance on a few prime movers; multiple parallel organizations; and reliance on volunteers. This paper is premised on the belief that a healthy, productive organizational model can help overcome all four barriers.

Inertia against novelty – The notion of a profession dedicated to designing the human environment in space is novel enough that most observers can understandably conclude, in the first decade of the 21st century, that it is premature. Those few people currently involved in designing human environments for space operate within the aerospace engineering industry; most of them do not consider themselves space architects. Even credentialed space architects play supporting roles in that traditional industry, where the

most vitally dominant concerns (e.g., survival, flight safety) are addressed outside the realm of architectural training or expertise and where the need for space architects is not compelling. Reversing this paradigm, to emulate the terrestrial model in which technical disciplines play supporting roles to an architect, requires an "acceptance transition" not yet in sight for space system design. This means two things: (1) available roles for space architects are fundamentally different from those available to terrestrial architects, and (2) achieving centrality of those roles is an uphill battle.

Few prime movers – The field of space architecture was instigated in the 1980s by a handful of energetic visionaries who began publishing in the field and infusing their passion into work within niches in academia, government, and industry. Some of these pioneers created institutions to promote advancement of the field. The prime movers catalyzed the weakly-connected global network of professionals interested in space architecture that exists now. This network is still fragile in the sense that the few "usual suspects" are still largely the ones motivating work, setting benchmarks, organizing events and products, and maintaining momentum. The community has not yet reached the crossover point beyond which its viability would be assured absent the prime movers, nor the size threshold at which prime-mover personalities cease to substantially affect community dynamics.

Multiple parallel organizations – Four primary space architecture institutions have emerged in the first growth phase of the field: a masters program at the University of Houston Sasakawa International Center for Space Architecture (SICSA); the AeroSpace Architecture SubCommittee (ASASC) of the American Institute of Aeronautics and Astronautics' Design Engineering Technical Committee (AIAA DETC); a new space architecture committee of the American Society of Civil Engineers (ASCE); and a new Space Architecture Study Group of the International Academy of Astronautics (IAA). In such a small total community, overlaps among these parallel organizations evidence relative immaturity, even fractures. How the separately-hosted organizations can work together to complement each other is not yet clear.

Volunteer labor method – With the exception of the academic SICSA, virtually all efforts to sustain and extend the field of space architecture are volunteer-based. Volunteer activities generally suffer from lack of dedicated time, lack of funding, and lack of predictable authority. These characteristics are analyzed in more detail two sections below.

A fifth barrier? – One might argue that these four barriers would be easily overcome were it not for a fifth, more fundamental barrier: there is very little foreseeable work for space architects for at least the next two decades. We can reasonably project five areas that need to design human environments in space in that timeframe: (1) small, private, suborbital-evolving-to-orbital passenger ships; (2) small, private space hotels; (3) small, U.S., cis-lunar, human spacecraft; (4) small, international lunar base(s); and (5) small, Chinese, cis-lunar, human spacecraft. Wildcards aside, this portfolio does not require more space architects than already exist. If space architects were in high demand, they would all be too busy working to talk much about it. But alas, the market demand is not high, and no scheme this paper could propose can increase it. Instead, the paper's goal is to help organize our efforts to convey the value of space architects for non-design jobs, to

assure professionalism for design opportunities that do emerge, and to continue preparation for an expanded future over the long term.

Desired end state

This section defines criteria by which we can recognize success as we shape the global community of professionals interested in space architecture. Note that none of these recommended criteria measures the viability of particular committees, organizations or institutions. Rather than measure how well we operate, or how hard we try, they measure the effectiveness of the outcome. View these criteria as a draft portrait of future success.

Recognizable, go-to brand – Space architects are viewed as a distinct category of professional, by those who fund space systems development, by those who practice terrestrial building, by those who specialize in defining human environments, and by each other. This brand of professional is sought by space system development projects challenged by requirements interactions so complex as to be intractable by numerical methods, and particularly when requirements are incorrigibly dynamic, as for the design of environments that directly support human occupancy or action. Space architects freely interact on par with the other professional disciplines required to develop, build, and operate space systems. They are capable of and respected for coordinating and leading those multidisciplinary efforts.

Efficient, responsive network – The community of space architects comprises a densely-connected global network that provides quick, capable, and helpful service to inquiries. Students, researchers, educators, professionals from other disciplines, the press, and potential hiring sponsors know where and how to ask for help in the field, and the community network mobilizes to meet their needs in a self-consistent way that enhances the professional stature of the field.

Professional standards – The boundaries of space architecture are defined and agreed to by the client industries. Standards for preparation and conduct of the practice of space architecture are documented and used to guide curricula and measure quality. As appropriate, certification criteria and authorities develop.

Diverse outreach – Commensurate with the integrative nature of architecture, the field has established robust interfaces with: (1) professional disciplines required to develop, build, and operate human space systems; (2) terrestrial professions not directly involved in space but whose services and products are relatable to it through space architecture; (3) sponsors including government agencies and private developers; (4) the institutions that educate and supply the next generation of professionals; and (5) media.

Opportunities for real work – The central or significant contributions by practitioners recognized as space architects steadily increase. Most members of the global community of space architects are gainfully and primarily employed in this capacity. Publishing and educating become secondary outlets.

Organizing to overcome the four barriers outlined earlier can accelerate the space architecture community toward this vision of success.

Characteristics of volunteer organizations

Now let us examine what we have to work with. We will consider three pragmatic challenges that face volunteer-based organizations. The first two are evident; the third requires more elaboration.

Lack of dedicated time – Volunteer-based organizations comprise volunteers. This tautology means with few exceptions (e.g., retirees) their members already have "day jobs." Volunteer efforts are carved out of personal time, and employment-based and family-based schedule conflicts are the norm. For the most part, "normal business hours" are off-limits to volunteer organizations. In the typical case, volunteers' employers understandably do not allocate or permit time to be spent on non-work-related activities, which is especially challenging for geographically-distributed volunteer organizations that require travel for physical meetings. Another derived challenge is that scheduling time for people to work together becomes a continual "best fit" exercise based on reconciling multiple, diverse personal schedules. Yet another derived challenge is that business infrastructure services are marginally more difficult to arrange outside of normal business hours. Modern communication techniques, including teleconferences but especially the internet, can be used effectively to compensate for the challenge of lack of dedicated time, because they help minimize travel and enable collective work to be asynchronous. These techniques can also directly amplify the geographic and cultural reach and diversity of volunteer organizations, and reduce the cycle time of decisions and action.

Lack of funding – Most volunteer-based organizations are non-registered not-for-profits, and have no significant or steady source of revenue. Not only are they not profit-making businesses, they are not businesses at all. They are just collections of people who have agreed to work together toward a shared objective. Small, advocacy-based organizations (e.g., an affiliation of space architecture professionals and enthusiasts) may have small accounts to collect costs and income, but they are generally too poor to invest in major growth initiatives, and are constantly on the prowl for sustaining and event-specific sponsors. The immediate implication of this challenge is a need for concerted attention to fund-raising as an enabler. Yet a derived challenge is that fundraising is not the reason the members joined, nor necessarily their skill strength. This in turn implies a need for membership outreach that goes beyond the intellectual kernel that is the group's *raison d'etre*.

Lack of authority – Losing sight of the first challenge – that volunteers volunteer because they want to – commonly hampers both effectiveness and human relations, which in turn become destructive forces that threaten organizations' health and survival. The most immediate implication – and conundrum – of a volunteer workforce is that people cannot simply be told what to do.

Volunteer organizations operate differently from authority-based organizations. These differences can be traced to their different incentive structures. Authority-based organizations typically derive incentives from explicit contracts: you do work for me, and in return I pay you cash and benefits. You sign application and acceptance paperwork and abide by the referenced rules of conduct, and I keep signing your paychecks. You derive financial security and access to information and other resources, but you give up

some degree of autonomy for these benefits. The degree of autonomy sacrificed varies along a spectrum; tenured faculty of universities and research institutions are at one end, while military personnel are at the other. Complex sociologies encrust the basic contract with layers of implicit codes of expected conduct reinforced by documented regulations that become bureaucratic – even Byzantine – in proportion to the size of the institution. Rarely does an employee "put his badge on the table" or sue her employer in a court of law, and rarely does an employer fire an employee outright or call him to account based on the "fine print." But joint recognition that these measures are nonetheless operable provides the foundation for the incentive structure. Sometimes employees share the inspiration of a common goal, and are emotionally committed to "go above and beyond" to attain it; but they are still employees and ultimately can be told what to do.

The incentive structure for volunteer-based organizations is comparatively fragile, because it depends completely on leveraging people's desire to expend their disposable resources: their personal time, energy, effort, ideas, and money. The only motivator such an organization has is shared vision: what is important, what could be accomplished, and sometimes the emotional satisfaction of "beating the odds" of "us against the world." Volunteers don't volunteer because they have to; they volunteer because they "believe in the cause." Recognize that the most effective authority-based organizations tap into this incentive structure as well; but the point is that volunteer-based organizations have *only* this to work with. It follows that the single most vital activity for volunteer-based organizations is the germination, cultivation, and stewardship of a shared sense of purpose. Activities that damage the shared sense of purpose directly destroy the incentive structure and are not sustainable. Volunteers will redirect their contributions elsewhere as soon as they come to believe an organization's motives are not aligned with their personal view of the vision.

In passing, it is interesting to note the well-documented trend in American industry that is evolving the traditional, economic-based employee incentive structure more toward the volunteer model. Particularly in times of heavy demand for key skills (e.g., the Dot-com boom), skill-carriers are more apt to demand intangible benefits including autonomy. Traditional American industries are finding that Generation-X and Generation-Y workers tend to act like volunteers: financial security is less important than intrinsic interest, and they are quick to take their time and talent elsewhere if their vision and the institution's purposes –or operating style – become misaligned. This is consistent with our model of volunteer-based organizations: they are the extreme case of demanding key skills in a "sellers' market."

Because volunteer-based organizations cannot simply tell people what to do, they can have trouble controlling activities and getting work done. Leaders must be careful saying "no" to volunteers desiring to take action; an easy – but counterproductive – result is simply that the volunteer withdraws, which is a no-win outcome. Similarly, volunteer leaders cannot directly order tasks to be done – this quickly becomes "pushing on a rope," in which case becoming more strident is ineffectual. Rather, management of a volunteer-based organization requires a skillful combination of two principles, one macro and one micro: (1) crafting and articulating a direction-setting vision strong enough to pull members collectively into alignment; and (2) diplomacy persuasive enough to successfully negotiate course corrections and other adjustments with individual members.

Again, these are often keys to success for authority-based organizations, but for volunteer-based organizations, they are the all.

Breakdowns in incentive alignment tend to cause failure in one of two ways. The first, immediately apparent, is that important work simply falls behind because otherwise capable members "go on strike" by choosing not to expend effort. The other, less immediately apparent but perhaps more dangerous in the long run, is that a few energetic members pick up the slack. The immediate tasks get completed, but personality-driven rifts among the membership may widen as a result, and the originally-shared vision may get hijacked as these few become the only active members. The rest retire to observe, tending eventually to leave the group altogether. In either case, the organization fails to take fullest advantage of its potential base, and progress becomes thin and frangible.

The most effective volunteer-based organizations appear from the outside to operate as though they were authority-based organizations. They are well-managed, meaning they are clearly organized; tasks are bounded and measurable; work is divided, shared, and mutually-reinforcing; assignments are self-aligned with members' skills and preferences; performance is enhanced by continuous feedback and positive reinforcement; spontaneous innovation is encouraged and integrated; and the sense of shared identity is stronger than individual identities.

As the size of a group increases, its intrinsic effectiveness becomes increasingly predictable by Gaussian statistics: a few outstanding participants, a few non-participants, and a majority who can accomplish a lot under the right kind of leadership. Extrinsic effectiveness is independent of the volunteers' basic competence; rather it is a function of the inherent tractability of the group's objective and its alignment with the volunteers' skills. The independent variable in this model, and therefore the most critical component of the effectiveness of a volunteer-based organization, is the skill of its leadership. Leaders' most central responsibility is to manage the three challenges just discussed.

Proffered schema

Our objective is to define a stable yet open-ended framework that can help organize the efforts of diverse volunteers and initiatives into a coherent, progressive agenda to facilitate steady growth of an active, global community of space architects.

We begin by cataloging topics and activities the community of space architects needs to address. In common with most volunteer organizations, the space architecture community needs both productive and supportive activities. Productive activities yield content that makes the community relevant outside itself: e.g., practicing design, educating others, providing consultation, publishing, and developing professional interfaces. Supportive activities provide administrative infrastructure inside the community that enables it to function: e.g., organizing, managing, marketing, and fundraising. These latter activities exist to support the productive activities; in a well-run organization they are effectively invisible to external beneficiaries. One measure of organizational efficiency is the ratio of resources expended on supportive vs. productive activities.

Binning volunteer-based space architecture activities into productive and supportive groupings helps clarify the role and purpose of each activity. Table 1 shows such a binning, which also provides an open-ended framework for proposing additional activities. This particular list of activity topics, defined in detail in the next section, is an orthogonal set.

Table 1. Division of Representative Activities into Productive and Supportive Categories

Productive Activities	Supportive Activities
Theory and history	Management
Professional practice	Professional meetings
Education	Events
Standards	Outreach
Publications	Financial
Design concepts	Awards
Executed designs	Affiliations
Participating specialties	Membership
Tools	

The key to effectively coordinating such a diverse set of activities is to manage each of them according to its unique considerations, while also managing all of them contextually. The activities listed in Table 1 may be grouped based on how they would be optimally coordinated – that is, "like with like." Figure 1 presents a candidate grouping, which can be used as a Work Breakdown Structure (WBS) for the total activity of the organization. The skills and preferences of individual leaders within the volunteer organization can then be mapped to the needs of these activity elements, to maximize both effectiveness and satisfaction.
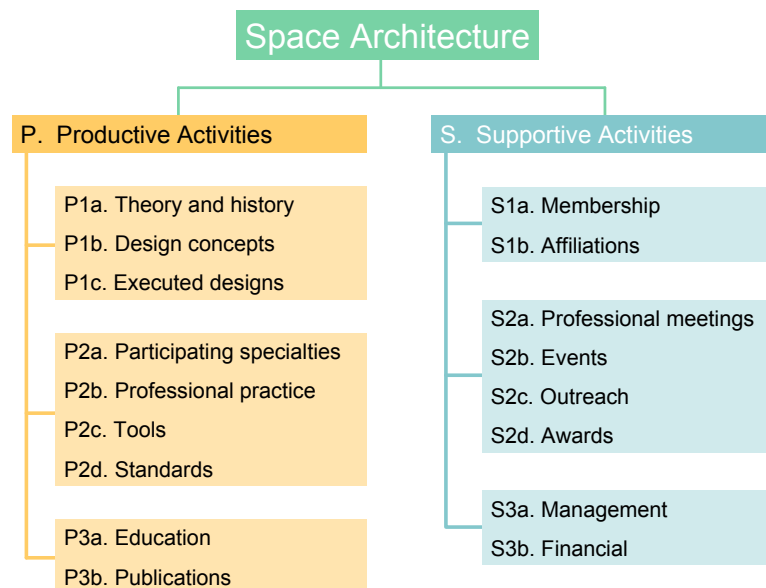

Figure 1. Work Breakdown Structure organizes management of diverse space architecture activities.

The activities are labeled per the binning (P = productive, S = supportive) and the groupings for easy reference. Table 2 elaborates the definition of each to provide further insight into their scope, and to justify the claim that they are orthogonal and complementary. Each is essential to some aspect of a comprehensive volunteer network used to promote growth of the field of space architecture. Whether or not the specific activities listed are adopted by community consensus, the WBS framework itself can be adapted as an organizational tool to accommodate an alternative or evolved set of activity definitions.

Several of the activities bear elaboration beyond the definitions in Table 2, to show how they can interact and provide a platform for indefinite growth and effectiveness of the community. For example, through activities P.1.b and P.1.c, the community produces an organized record of conceptual and executed space architecture designs. This oeuvre can then be used by S.2.c to promote the value of space architecture to a wider stakeholder community, and by P.1.a to generate new theoretical and critical analyses. Through P.2.a and P.2.b, the community maintains a rich network of service providers available to each other and to new stakeholders. Parties interested in space architecture design, consulting, speaker, or editorial services can then be reliably matched with appropriate providers. Over time, P.3.b generates annotated libraries of critically-reviewed literature, providing a basis for scholarship, reference by this and other fields, and incremental advancement of the field.

Activity S.1.b enables coordination across space architecture-related committees and initiatives that can be created within already-established professional organizations. For example, the ASASC of the AIAA DETC, as the official space architecture outlet adhering to unique AIAA rules, guidelines, and objectives, can do so as one of many affiliated organizations all working to infuse awareness of space architecture throughout related fields. The WBS thus facilitates a "meta-organization" whose central focus is the promotion and productivity of a global network of professionals interested in space architecture, compatible with but not dominated by the local agendas of pre-existing organizations with other, more diffuse purposes.

Activity S.3.b integrates funds from S.2.c (which seeks financial sponsorship from stakeholder sources), P.3.b (which seeks royalty revenue from publications), and S.1.a, S.2.a and S.2.b (which seek positive balance from membership dues, professional meeting fees, and public events, respectively) to create an income stream that can be used to pay activities costs throughout the WBS. A net positive balance enables growth in the size and sophistication of the community's services and activities.

Table 2. Taxonomy of the reference space architecture WBS.

Bin	Group	Activity	Scope Definition with Examples
P. **Productive Activities**	**1. Product** – knowledge and output accumulated by the space architecture community	**a. Theory and History**	Theoretical and historical analyses and derivations of design principles. Art-historical, contextual and technical evaluations of designs and design requirements.
		b. Design concepts	Documented design projects proposed by members, including drawings, digital or physical models, prototypes, and narrative descriptions.
		c. Executed designs	Documentation of designs that have been executed for sponsors and used by clients, including reviews and usage analyses.
	2. Process – elements used by the community to create knowledge and provide services	**a. Participating specialties**	Development of professional interfaces with specialties integrated through architecture, e.g., aerospace engineering, environmental engineering, interior design, landscape, horticulture, aquaculture, materials, art, construction, construction management, urban planning. Contact-network of interested professionals from whom these services can be obtained. Reviews, assessments and testimonials of these providers.
		b. Professional practice	Definition and organization of the professional practice of space architecture. Specification and certification of licensure criteria. Networking for provision of services by space architects, including design and consultation. Reviews, assessments and testimonials.
		c. Tools	Reviews and recommendations of design tools, methods, and processes. Adaptation and development of new capabilities specialized for space architecture.
		d. Standards	Development and codification of design standards for space architecture, e.g., design principles, parameter ranges, dimensions, materials.
	3. Sharing – communication, and development of knowledge in others	**a. Education**	Curricula for training space architects and associated professionals. Catalog of relevant university programs. Reviews and quality comparisons. Advice to young and/or new professionals. Guest lectures. Developmental activities to involve new members in the space architecture community.
		b. Publications	Books, chapters, papers, articles, press releases, pamphlets, retrospectives, monographs. Peer-review services. Literature reviews, editorials, and editing services.
S. **Supportive Activities**	**1. Relationships** – our people and networks	**a. Members**	Maintaining and expanding the directory of space architecture practitioners, teachers, students. Providing communication means (e.g., listserves) to sustain membership communications. Maintaining active communication and exchange within the community.
		b. Affiliations	Interfaces with related professional organizations, e.g., AIA, AIAA, ASCE, UIA, international space agencies, and universities. Upkeep of and coordination among special-purpose instantiations of the space architecture community within these organizations.
	2. Connections – staying in touch with each other and the outside world	**a. Professional meetings**	Conferences, symposia. Solicitation and review of papers, plenary speeches, and posters. Session organization, chairship, and rapporteurship. Minutes and reports.
		b. Events	Design competitions, juried reviews, workshops, design exhibitions, design demonstration projects. Promotional appearances.
		c. Outreach	Marketing space architecture to the client base, supplier base, and wider stakeholder community. Advertising for members and professional linkages, and fundraising of sustaining and developmental funds.
		d. Awards	Creation, selection, and presentation of space architecture-related awards, fellowships, scholarships, and other recognition to professionals and students.
	3. Overhead – organizational infrastructure	**a. Management**	Coordinating activities P.1-3 and S.1-3. Assigning and monitoring tasks to sustain, enlarge, and enrich the space architecture community. Organizing new initiatives and assuring momentum throughout the community. Administrative meetings and telecons.
		b. Financial	Managing financial resources that enable S.3.a and its component activities.

The final step of the schema is to map volunteer action itself into a WBS like this example. Doing so aligns responsibility assignments with the actual work organization, which minimizes authority conflicts. Two principles are key. First is to assign leaders for each of the "middle layer" activity groupings (Product, Process, Sharing, Relationships, Connections, and Overhead), which yields several benefits: (1) it creates a right-sized, core leadership team comprising about half a dozen people who can effectively coordinate the 17 or so distinct activity areas; (2) it improves on the traditional "committee" organization by elevating specific, content-based roles to the leadership team rather than vague, bureaucratically-defined roles like secretary, treasurer, etc.; (3) it increases the probability of administrative success because the activities accountable to each leader are grouped "like with like;" (4) it maximizes the opportunity for volunteer satisfaction, which underpins organizational effectiveness; and (5) the leadership team provides a natural way to create, describe, and communicate a robust strategic vision with which task leaders throughout the organization can align their individual actions.

The second key principle is inherent in the division into Productive and Supportive activity types. Volunteers gravitate naturally to a preference for one or the other type – some people have little tolerance for "administrivia" while others favor these inside, helper roles. But both kinds of work need to be done for the organization to be both relevant and functional, so a straightforward approach to reinforcing members' empathy for each others' value to the whole is to encourage each volunteer to participate in at least two activities: one Productive and one Supportive.

The structure and principles just proffered contain several clues to successful administration of the space architecture community as a volunteer-based organization:

1. Spreading the load – Leaders and contributors can be apportioned throughout the partitioned work structure, which can yield more robust continuity that is less vulnerable to "burning out" a few seemingly-tireless volunteers.

2. Division of labor – Grouping "like with like" activities allows volunteers to find roles that suit their inclinations and talents, e.g., fundraising, leadership, editing, event organization, reviews, database management, marketing.

3. Micro-projects – By further subdividing the work to be done, leaders can involve and successfully task individuals who have very limited time to contribute. People can be granted end-to-end accountability for "micro-projects," with greater confidence the work will get done and the results will mesh with the whole. A key example would be fundraising projects within the Outreach activity S.2.c.

4. Selecting the focus – The WBS provides a framework for the leadership team to strategically monitor, reinforce, and accelerate individual activities within the overall context. Tactical adjustments can respond to fluctuating availability of volunteer talent and interest in various aspects of the total work to be done.

5. Robust communications – All subdivided organizations learn that clear, continuous, and accurate communication is essential for genuinely complementary action. Offloading the management function (S.3.a) – which contains the traditional committee roles of vice president and secretary – from the

leadership of content-based task areas helps facilitate its focus on effective communication.

Conclusion and Call

The global space architecture community has an inchoate charter not comfortably contained within any existing institution. At the same time the community is still fragile and immature. There is much to do to secure the future of space architecture as a viable, thriving field within our working lifetimes. And there are limited resources to work with, comprising mostly volunteerism and the energies of a few people.

However, the community can self-organize along the lines described herein, to more effectively coordinate a complete set of productive and supportive activities all focused specifically on advancing the field of space architecture. This structure admits the conditions for successful volunteer effort, it moves beyond dependence on a few individuals, and it provides an open-ended framework to accommodate multiple outlets in the form of liaison committees inside established professional organizations, curricula inside universities, and design principles inside companies and agencies. It organizes information and action to create and manage a legacy, and cultivate the next generation of professionals.

The meta-organization this paper recommends is not about individuals or institutions – rather it is about applying all the means we have to create a bona fide, new field of study and practice that will help open new horizons for one of the world's oldest professions.